Abstract

Over the past two decades, nanometer-sized materials and devices have attracted much interest, due to the broad range of current and prospective applications of nanomaterials in electronics, high-density data storage, chemical sensing, drug delivery, medical diagnostic systems, and nanocatalysis. The explosive growth in solution processed semiconductors has driven new emerging technologies for photonic sources and adaptive optics: organic, hybrid, perovskite and all inorganic-nanoparticle systems have developed significantly over the last four decades due to the promise of cheap, flexible displays and lights and the sources to power them. Though they have impacted the consumer landscape, such devices have not dominated the market as has been long predicted, as a roadblock in effective nanoparticle device development is homogeneity, uniformity and effective size control, in the materials and at various interfaces. Self-assembly of amphiphilic block copolymers is a model example of a "bottom-up" approach to the construction of nano-objects on large areas. Di-block copolymers, due to their amphiphilic nature, spontaneously form core-corona micelles in selective solvents. Using the micelles as “nanoreactors” allows the nearly universal formation of highly controllable nanoparticles. The hydrophilic block typically has high affinity to coordinate with metal reactants allowing control of the nanoscale chemical reaction and nanoparticle growth. Reverse micelles are used as carriers for the metal precursor and upon removal form highly organized monodispersed nanoparticles. Particles are possible with a very narrow size distribution, less than 2% variation in the particle diameters, which can be deposited on any surface at room temperature with highly controlled spacing and spatial organization. Over the years, we have used the same basic micellar diblock copolymer nanoreactor to produce monodisperse oxide, dielectric, perovskite, metal and core-shell nanoparticles. This gives us a unique opportunity to uncouple the impact of the nanoparticle size and dispersion from the fundamental materials properties in tuning magnetic, electrical, and optical responses. In this talk, I will highlight some of the work we have done incorporating nanoparticles for various applications, with a vision of developing a roadmap for further developments of bespoke functional nanoparticles tailored for high performance.